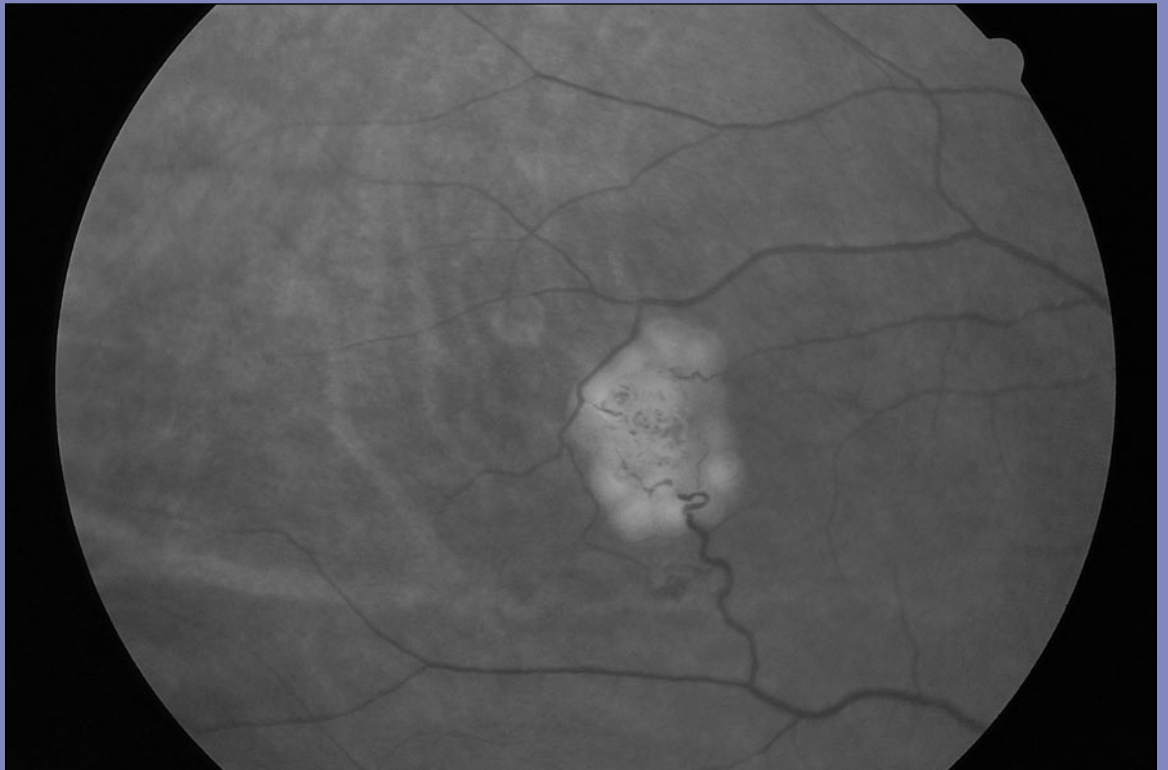


Laser Photocoagulation and Photodynamic Therapy for Retinal and Choroidal Disease



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BRANCH RETINAL VEIN OCCLUSION: MACULAR EDEMA

Laser photocoagulation is indicated for the treatment of branch retinal vein occlusion (BRVO) that is complicated by visual loss related to macular edema. The BRVO Study established the following eligibility criteria: (1) recent onset of BRVO (within 3–18 months); (2) visual acuity of 20/40 or worse; (3) sufficient clearing of intraretinal hemorrhage and no foveal hemorrhage; (4) fluorescein angiogram demonstrating macular edema involving the fovea with good perfusion; and (5) no other ocular disorder contributing to visual loss.

Technique

Most ophthalmologists observe patients with acute BRVOs for 3 months to allow for spontaneous resolution. If after that time vision remains 20/40 or worse and there has been sufficient clearing of the intraretinal hemorrhage, a fluorescein angiogram is obtained to assess macular perfusion and the extent and location of leakage. If macular edema accounts for the visual loss (rather than macular ischemia), macular laser treatment is recommended.

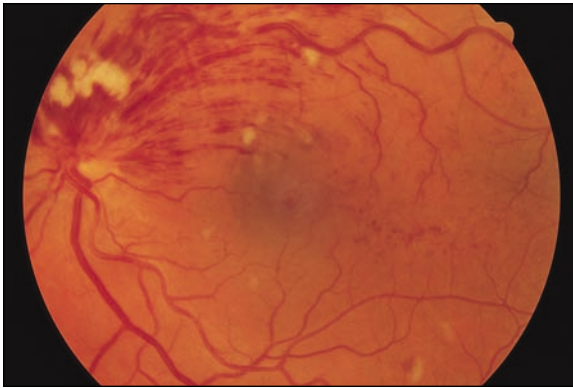
Patients must provide informed consent before undergoing laser photocoagulation. Photocoagulation is performed using a slit lamp delivery system with a fundus contact lens and topical anesthesia. Several commercially available lenses are designed to optimize viewing of the macula. Laser settings are as follows: 100- μ m to 200- μ m spot size; 0.1- to 0.15-second duration; and intensity to achieve a light to medium retinal burn. Treatment involves a grid pattern of laser energy over the area of capillary leakage, extending no closer to the fovea than the edge of the foveal avascular zone. Treatment should not extend beyond the major vascular arcades (unless there is associated neovascularization/vitreous hemorrhage). Burns are placed approximately one burn width apart throughout the involved area.

Complications

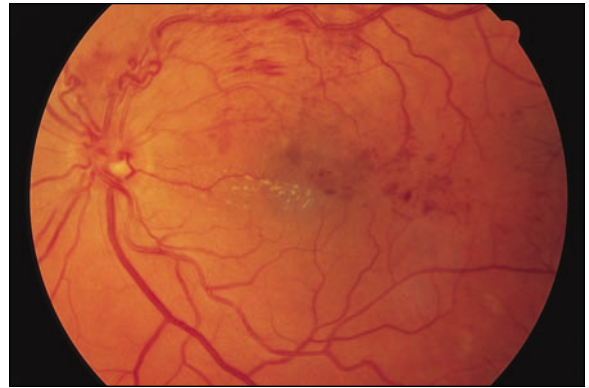
Complications of macular laser treatment for BRVO are uncommon, but they include loss of vision, central and paracentral scotomas, choroidal neovascularization, and subretinal fibrosis. Surgeons must identify the center of the macula to avoid inadvertent foveal burns. Having the patient fixate on the laser-aiming beam, while the laser is in the standby setting, may identify the center of the macula. Areas of retinal hemorrhage should be avoided to reduce the risk of retinal damage and epiretinal membrane formation.

Follow-up Considerations

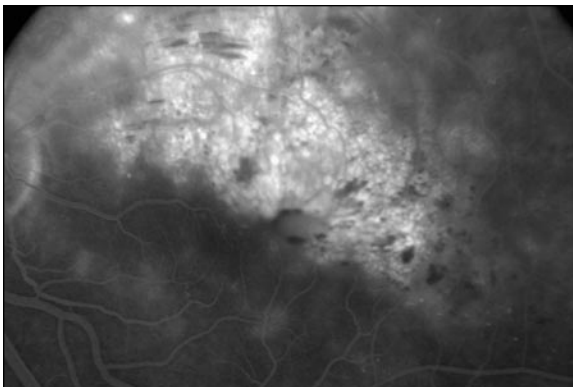
Patients are evaluated 3 months after laser photocoagulation. Additional laser treatment may be considered in those whose condition does not respond to the initial treatment.



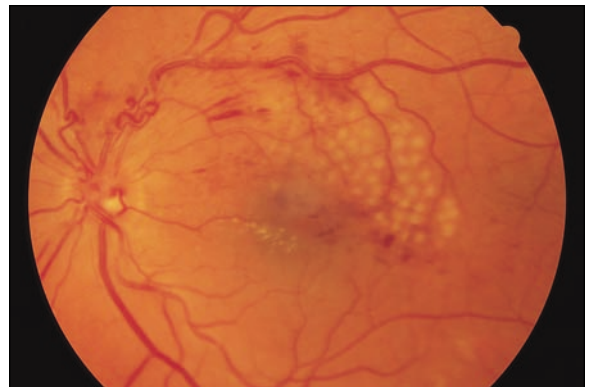
A 56-year-old man presented with acute visual loss in his left eye. He was diagnosed with a superotemporal branch retinal vein occlusion. His blood pressure was 160/94 mm Hg, and he was referred to his primary care doctor for evaluation and treatment of hypertension.



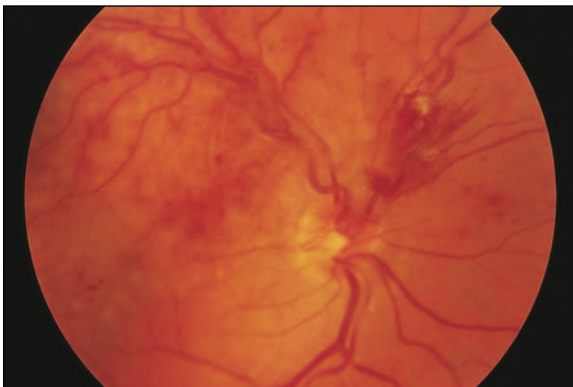
During the subsequent 3 months, visual acuity in the left eye remained 20/50. His examination revealed reduction of the intraretinal hemorrhage but more prominent macular edema and lipid exudate.



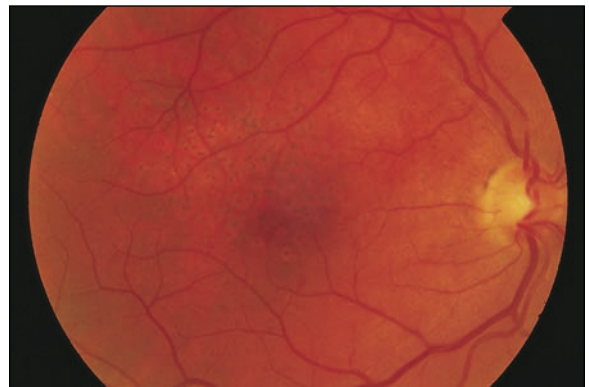
Fluorescein angiogram of the left eye of the same patient in at 3-month follow-up reveals significant leakage throughout the superior macula with relatively good vascular perfusion.



Laser photocoagulation was performed. A grid pattern of laser energy was applied to the area of retinal thickening using the following parameters: 100- μ m spot size burns placed one burn width apart; 0.1-second duration; and power intensity to achieve a moderately white burn (100 mW).



This example of branch retinal vein occlusion is associated with macular edema. Laser photocoagulation was performed.



This fundus photograph of the same eye was taken approximately 6 months following laser treatment. The macular edema has resolved. Note the hyperpigmented spots at the level of the retinal pigment epithelium corresponding to the laser burns.

BRANCH RETINAL VEIN OCCLUSION: NEOVASCULARIZATION

Scatter laser photocoagulation is indicated for the treatment of branch retinal vein occlusion (BRVO) that is complicated by the development of neovascularization and/or vitreous hemorrhage. The risk of neovascularization and/or vitreous hemorrhage is associated with the extent of retinal ischemia in the distribution of the BRVO. Neovascularization usually occurs at the junction of the perfused and nonperfused retina but may be found at the optic disc or a distant site.

Technique

The mechanism for the development of neovascularization presumably involves the release of vasogenic substances from the ischemic retina. Scatter laser photocoagulation is applied to the peripheral retina in the distribution of the BRVO to reduce the stimulus for neovascularization and induce regression of the new vessels. It is important to distinguish peripheral scatter laser photocoagulation in the distribution of the BRVO from pan-retinal photocoagulation, which involves scatter laser photocoagulation of the entire peripheral fundus.

Informed consent must be obtained from the patient before scatter laser photocoagulation is performed. Laser therapy usually is completed in one session using topical anesthesia. Both slit lamp and binocular indirect ophthalmoscopic laser photocoagulation delivery systems may be used. A variety of wide-field fundus contact lenses is available to facilitate peripheral scatter laser application. The green wavelength is preferred for most patients; however, the red wavelength may be used in cases of significant cataract or vitreous hemorrhage. Typical laser parameters include 200- μm to 500- μm spot size; 0.1-second duration; and intensity to obtain a moderately white retinal burn. Spots are placed one-half to one burn width apart in a scatter pattern throughout the involved quadrant or region. The posterior portion of the BRVO should be demarcated with two or three rows of laser burns. Treatment is then extended in a posterior to anterior direction to reduce the risk of extension into the macula.

Complications

Complications of peripheral scatter laser photocoagulation are uncommon. Care must be taken to avoid inadvertent laser treatment of the macula.

Follow-up Considerations

Patients are reexamined 6 to 8 weeks following completion of the scatter laser photocoagulation. Additional laser photocoagulation may be applied in eyes that fail to respond to initial treatment.



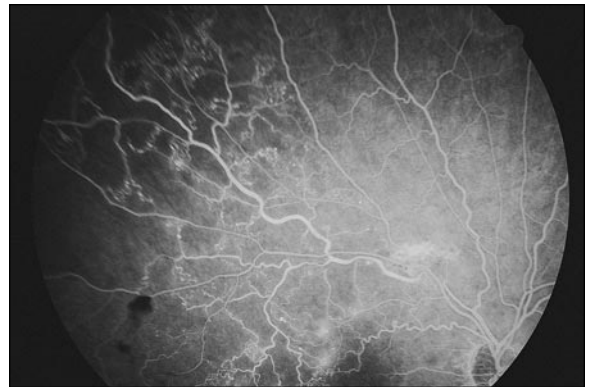
A 68-year-old man presented with complaints of floaters and mild visual loss in the right eye. He had a history of "broken blood vessels." The fundus photograph reveals a chronic superior branch retinal vein occlusion with venous sheathing and telangiectatic capillaries.



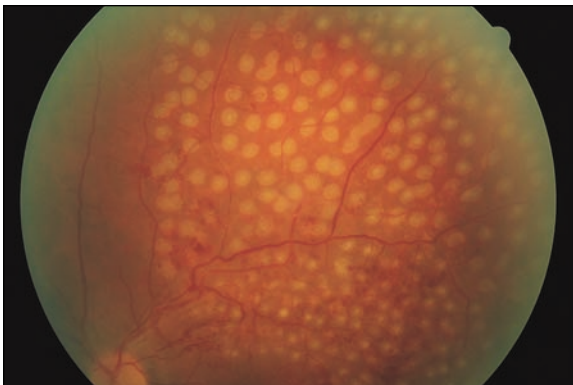
The same patient has preretinal hemorrhage along the inferotemporal vascular arcade in the right eye.



Fluorescein angiogram of the same patient reveals an ischemic branch retinal vein occlusion. The hyperfluorescence is consistent with neovascularization along the superotemporal vascular arcade at the site of the vein occlusion.



A peripheral view of the same eye demonstrates diffuse hypofluorescence consistent with widespread nonperfusion in the distribution of the occlusion. Note the neovascularization at the junction of the perfused and nonperfused retina.



This fundus photograph was taken immediately following laser photocoagulation of a patient with ischemic branch retinal vein occlusion complicated by neovascularization and macular edema. Macular grid and peripheral scatter patterns of laser photocoagulation were performed.

CENTRAL SEROUS CHORIORETINOPATHY

Most cases of central serous chorioretinopathy resolve spontaneously without the need for treatment. However, laser photocoagulation may be indicated for patients with the following features: duration greater than 4 months; history of visual loss in the same or fellow eye from previous episodes of central serous chorioretinopathy; the need for rapid recovery of vision; atypical central serous chorioretinopathy with large bullous retinal detachment; and central serous chorioretinopathy associated with corticosteroid use.

Technique

Informed consent must be obtained from the patient prior to performing laser photocoagulation for central serous chorioretinopathy. A fluorescein angiogram should be completed to identify the leakage site and ensure that laser burns can be applied safely without involving the fovea. Laser photocoagulation should be performed with a slit lamp delivery system. Central serous chorioretinopathy has been successfully treated with all available wavelengths of laser (yellow, green, and red). A variety of fundus contact lenses is available to improve visualization and treatment of the macula. Laser is applied directly to the leakage site. Common laser parameters include 100- μm spot size; 0.1- to 0.2-second duration; and laser intensity enough to produce a moderately white burn.

Complications

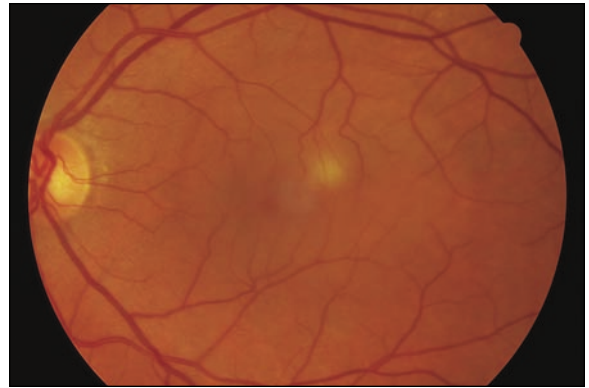
Laser photocoagulation is safe and effective for central serous chorioretinopathy, with little risk of significant adverse effects. Special care must be exercised to avoid inadvertent laser burns on the fovea. Initially, laser intensity should be low and carefully increased to avoid the risk of choroidal rupture and secondary choroidal neovascularization.

Follow-up Considerations

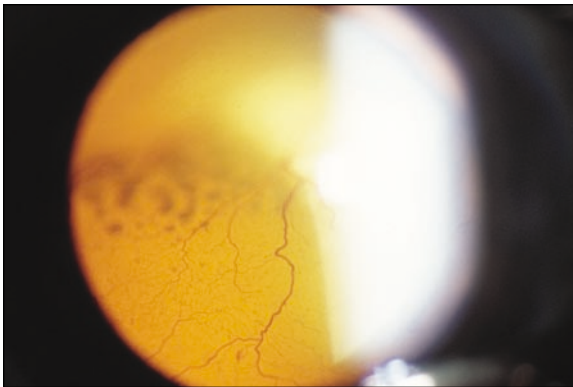
The subretinal fluid usually resorbs within 6 to 8 weeks following laser photocoagulation. Retroretinal protein precipitates may be more prominent during the resolution phase of central serous chorioretinopathy. Recovery of vision may lag behind resorption of the subretinal fluid.



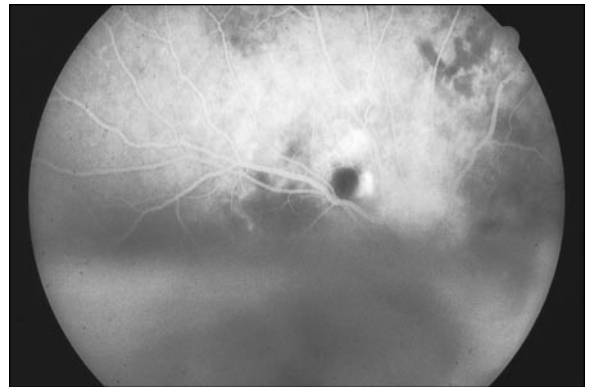
A 53-year-old woman developed central serous chorioretinopathy following a corticosteroid injection for joint disease. Her fluorescein angiogram revealed a hyperfluorescent spot that continued to leak throughout the study.



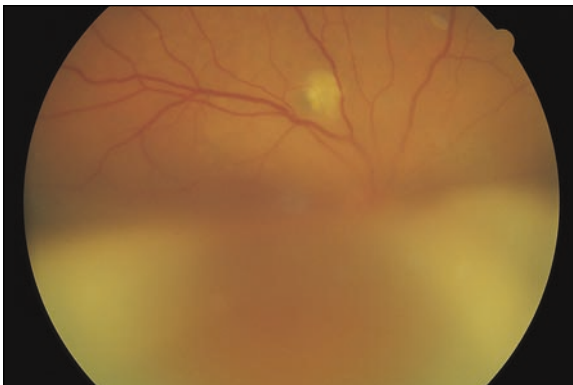
The same patient elected to have laser photocoagulation. This fundus photograph, taken immediately after laser treatment, demonstrates a moderately white burn applied directly to the leakage site. The subretinal fluid resolved during 6 weeks after laser therapy.



A 26-year-old man developed atypical central serous chorioretinopathy characterized by a bullous serous retinal detachment. This slit lamp photograph shows the retina located just behind the lens. Note the large subretinal protein deposits.



Fluorescein angiogram reveals a hyperfluorescent spot located above the superotemporal vascular arcade. Leakage was significant throughout the fluorescein study.



Laser photocoagulation was performed on the same patient. A moderately intense burn was placed at the leakage site. The laser parameters were 100- μ m spot size; 0.2-second duration; and intensity to produce a moderately white burn (150 mW).



The subretinal fluid resorbed during 6 weeks after laser treatment. Extensive retinal pigment epithelial abnormalities and subretinal fibrosis are seen.

CENTRAL RETINAL VEIN OCCLUSION

Panretinal laser photocoagulation (PRP) is indicated for the treatment of central retinal vein occlusion (CRVO) complicated by the development of iris or angle neovascularization/neovascular glaucoma. Iris or angle neovascularization/neovascular glaucoma develops in response to widespread retinal ischemia. Panretinal laser photocoagulation is applied to the ischemic peripheral retina to reduce the stimulus for neovascularization and induce regression of the new vessels. Laser photocoagulation for macular edema secondary to CRVO may help to reduce the macular edema but does not appear to have a significant impact on visual acuity.

Technique

Eyes with CRVO are followed up closely for the development of iris (NVI) or angle (NVA) neovascularization. Once NVI and/or NVA is detected, prompt PRP is recommended to reduce the risk of neovascular glaucoma.

Informed consent must be obtained from the patient prior to performing PRP. Because of the devastating effects of neovascular glaucoma, PRP usually is performed in a single session with use of retrobulbar anesthesia. Both binocular indirect ophthalmoscopic and slit lamp laser photocoagulation delivery systems may be used. A variety of wide-field contact lenses are available for standard PRP. Many of the commercially available lenses magnify the spot size by 1.5 to two times and provide an inverted and reversed image of the fundus. The green wavelength is most commonly employed; red may be used in patients with significant cataract or vitreous hemorrhage. Common laser parameters are 200- μ m to 500- μ m spot size; 0.1- to 0.2-second duration; and intensity to produce a moderately white burn. The average number of 500- μ m spots needed to complete PRP is approximately 1600. Laser burns are spaced one-half to one spot width apart.

The placement of laser therapy in a posterior to anterior direction helps to reduce the risk of inadvertent extension into the macula. The posterior fundus is demarcated with two to three rows of laser burns. The posterior border should be placed approximately 1 disc diameter from the optic disc nasally and from the major retinal vascular arcades superiorly and inferiorly. The temporal border is placed at an imaginary line located approximately 2 disc-to-fovea diameters from the optic disc.

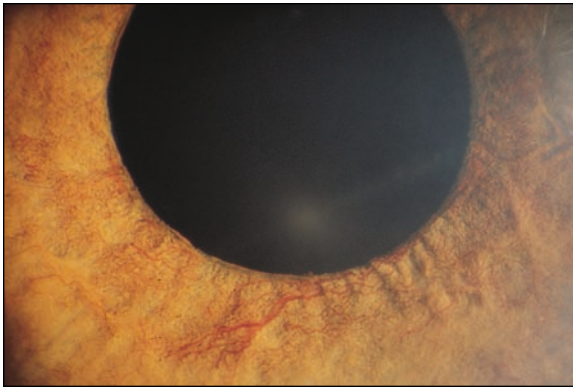
In addition to medications to lower intraocular pressure, some ophthalmologists recommend using topical corticosteroid and cycloplegic eyedrops to enhance patient comfort and reduce the risk of postlaser choroidal effusions.

Complications

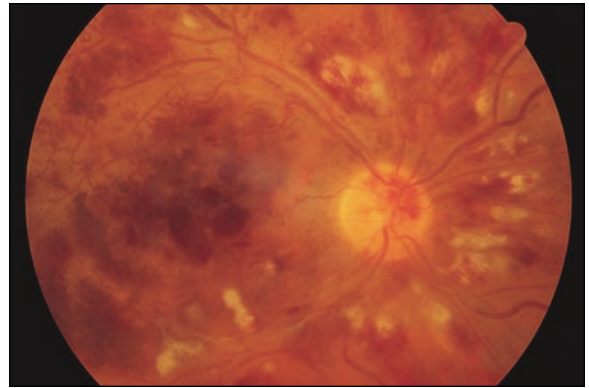
Complications of PRP include blurred vision, nyctalopia, visual field constriction, poor color discrimination, transient myopia, accommodation defects, corneal burns, narrow-angle glaucoma, iris burns, lens opacities, inadvertent macular burns, macular edema, exudative macular detachment, ciliochoroidal effusion, choroidal/choriovitreous neovascularization, optic neuropathy, and complications of local anesthesia (globe trauma, retrobulbar hemorrhage).

Follow-up Considerations

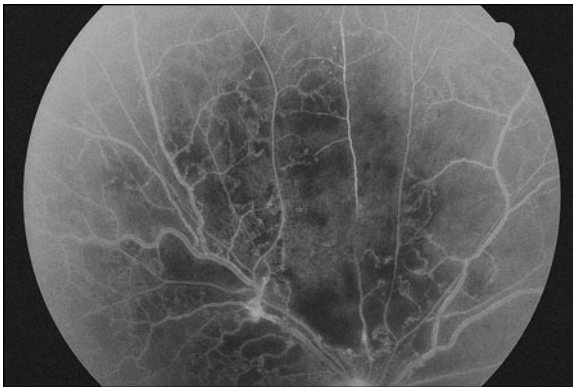
Patients are reexamined 1 week following PRP to assess the response to laser therapy and measure the intraocular pressure. Additional laser photocoagulation may be necessary, unless the new vessels have significantly regressed. Supplemental laser burns may be placed between previous burn sites and to the far peripheral retina using a three-mirror lens or a binocular indirect ophthalmoscopic laser delivery system. Gonioscopy is performed to assess regression of NVA and the extent of peripheral anterior synechiae.



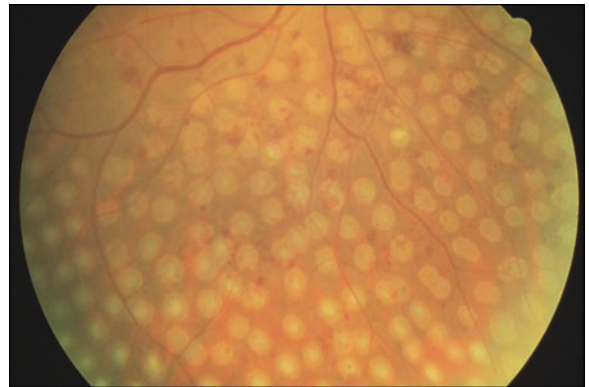
Laser photocoagulation is indicated for the treatment of central retinal vein occlusions complicated by iris or angle neovascularization/neovascular glaucoma. Iris neovascularization may be seen along the pupillary margin, the iris face, or anterior chamber angle.



Laser photocoagulation may reduce macular edema but does not have a significant impact on visual acuity. As a result, macular laser is generally not considered unless the patient is younger than 65 years.



Iris neovascularization/neovascular glaucoma develops in patients with ischemic central retinal vein occlusion. This fluorescein angiogram shows widespread capillary nonperfusion in a patient with neovascular glaucoma.



Prompt panretinal photocoagulation treatment when early iris or angle neovascularization appears should diminish the development of neovascular glaucoma. This fundus photograph demonstrates a typical laser photocoagulation pattern.

CHOROIDAL NEOVASCULARIZATION

In the era of photodynamic therapy, thermal laser photocoagulation should probably be limited to treating patients with clearly defined choroidal neovascular membranes (CNV) that do not involve the foveal center. Treatment should largely be confined to those patients with CNV secondary to age-related macular degeneration (AMD), the presumed ocular histoplasmosis syndrome (POHS), or idiopathic causes. Choroidal neovascular membranes secondary to conditions such as high myopia, angioid streaks, choroidal ruptures, and others can be considered by the treating surgeon.

Technique

High-quality color photography and fluorescein angiography transiting the eye to be treated are mandatory to determine the need for treatment and to help guide the treatment. Ideally, these images should be obtained within 72 hours of treatment. A decision to offer treatment is made only after the angiogram is thoroughly scrutinized under magnification and a careful stereoscopic evaluation of the macula has been done. When providing an informed consent, patients must understand that this kind of laser photocoagulation will result in a dense paracentral scotoma. Patients also need to understand that recurrence, especially in the setting of AMD, is frequent if not universal given enough time.

Treatment may be done with use of a high-magnification fundus contact lens and topical anesthesia, if the patient can reliably fixate with the fellow eye. If the patient cannot reliably keep from moving the eye during laser treatment, then retrobulbar or peribulbar anesthesia is preferred. A high-magnification copy of a midphase frame of the angiogram needs to be close at hand to help identify landmarks and guide treatment. The slit lamp delivery system is used, and argon green or krypton red laser wavelengths are preferred. Red may be advantageous in treating lesions with associated subretinal hemorrhage or those within the papillomacular bundle. The treatment needs to be carefully planned ahead of time, as all areas of both occult and classic choroidal neovascularization need to be completely ablated. If proximity to the fovea permits, an effort should be made to overlap the edges of the CNV so that 100 μm of normal retina is also treated to reduce the risk of recurrence.

The desired end point is a chalky white burn. To achieve this and minimize the risk of perforation of Bruch's membrane and/or hemorrhage, a long-duration, large, and low-intensity burn is preferred to a high-power, short-duration, smaller burn. Test burns with a 200- μm spot size and at least 0.2-second duration are placed within the neovascular complex away from the fovea. The power is titrated up from 100 mW to achieve a chalky white burn and to observe the spread of the laser burn. Once the desired power has been determined, the foveal edge is treated first with overlapping 200- μm spots. If 100- μm overlap of the CNV is desired, the 200- μm burn is centered on the edge of the CNV. If less overlap is needed, the burn is centered inward. A second and third contiguous row of laser burns is then applied inside this foveal edge. Burns are placed in an overlapping

fashion to ensure complete coverage. Once this foveal edge has been treated, the lesion can then be outlined with overlapping 200- μm burns of adequate intensity. The non-foveal edges are overlapped by 100 μm . The lesion can then be filled in with larger, longer-duration burns. The desired end point is a uniform chalky whiteness of the entire neovascular complex. Once treatment has been finished, a careful comparison should be undertaken between the high-magnification mid-phase angiogram and the eye, so that additional treatment can be done at the same sitting, if necessary.

Complications

A common complication of this type of intense laser treatment is hemorrhage, generally from bleeding CNV or perforating Bruch's membrane. A bubble may be seen if this occurs. Bleeding is best controlled with increasing the pressure on the contact lens to raise intraocular pressure and control oozing. This pressure should continue for at least 30 seconds after the bleeding has stopped to allow it to clot. While such bleeding can be alarming, it is not an indication to discontinue treatment. Treatment should continue but at a lower laser power. It is important to remember that a break in Bruch's membrane is itself a risk factor for the development of CNV. Special care should be taken during the follow-up period to monitor for this complication.

The most dreaded complication of this type of thermal laser photocoagulation is inadvertently burning the fovea. This adverse event should be avoidable with careful prelaser planning, identification of important landmarks on fluorescein angiography, and careful discussion with the patient to ensure proper fixation or, failing that, adequate anesthesia.

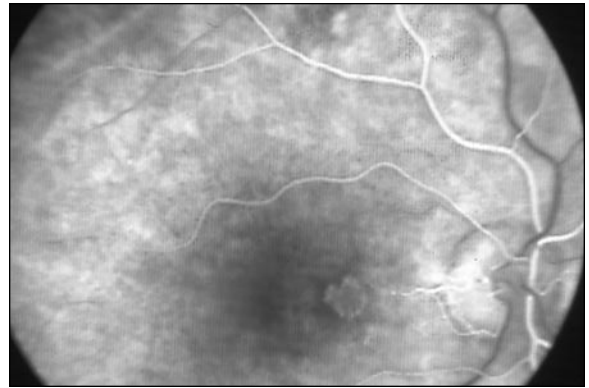
Persistence (less than 6 weeks following treatment) or recurrence of CNV is a frequent problem. This likely occurs universally given enough follow-up in patients with CNV secondary to AMD. Patients need to be counseled to return if they notice any new distortion or other significant visual changes. Recurrences that do not involve the foveal center may be re-treated with thermal laser photocoagulation. It is useful to take an immediate posttreatment photograph to help the clinician identify potential areas of inadequate treatment and to help guide any potential future treatment.

Follow-up Considerations

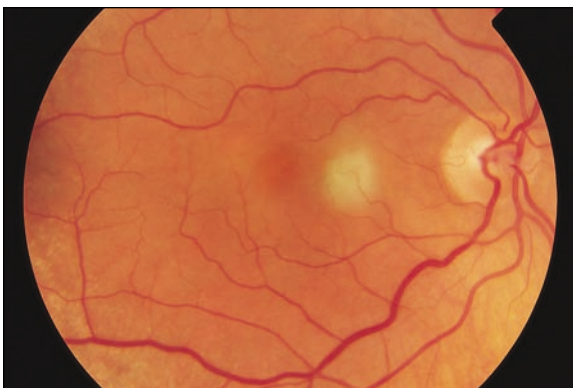
Patients should be seen 2 to 3 weeks following laser treatment and undergo fluorescein angiography. At this first postlaser visit, much of the subretinal fluid that may have been present may have resorbed, although some swelling may persist within the laser scar. Fluorescein angiography usually shows central hypofluorescence surrounded by a rim of hyperfluorescence. The presence of any leakage almost certainly indicates persistence/recurrence and, after correlation with the clinical examination, additional treatment is undertaken as necessary. These patients do need to be followed up closely with clinical examination and fluorescein angiography. An interval of every 2 to 4 weeks for the first 3 to 4 months is quite reasonable.



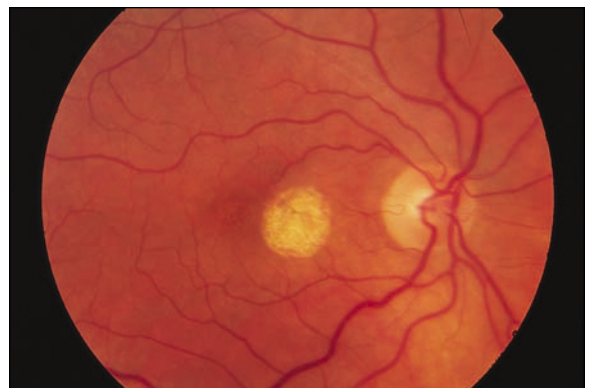
This 65-year-old woman presented with visual loss in her right eye. Her examination revealed a yellowish gray lesion associated with subretinal fluid located nasal to the fovea.



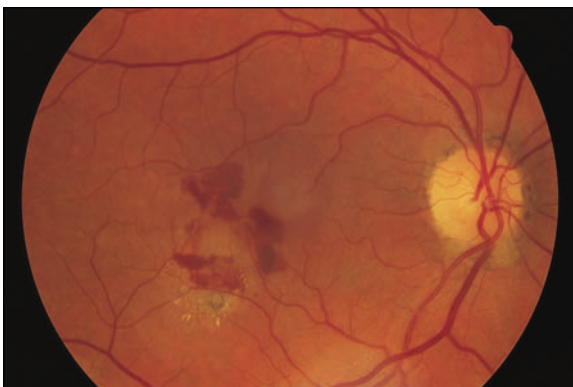
Fluorescein angiography of the same patient demonstrates a classic, well-defined extrafoveal choroidal neovascular membrane.



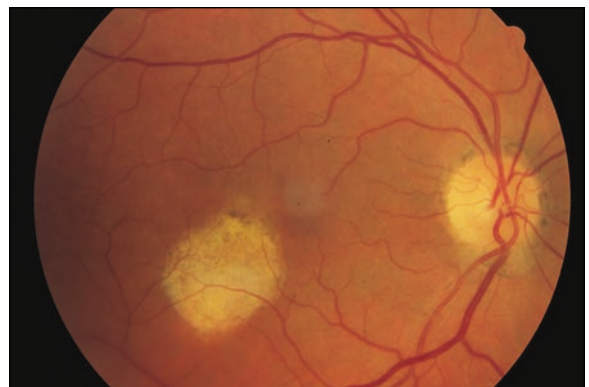
The same patient elected to undergo laser photocoagulation. This fundus photograph was taken immediately following treatment. Intense laser burns cover the entire neovascular complex.



One year after treatment, the patient has a well-defined chorioretinal scar corresponding to laser photocoagulation. No recurrence is evident.



This 62-year-old woman with presumed ocular histoplasmosis syndrome presented with distortion and reduced vision in her right eye. She had a history of visual loss in her left eye related to choroidal neovascularization. Note the subretinal blood, fluid, and lipid.



Fluorescein angiography of the same patient demonstrated a classic extrafoveal choroidal neovascular membrane, and laser photocoagulation was performed. This fundus photograph taken almost 2 years after treatment reveals an atrophic scar with no evidence of recurrence.

DIABETIC RETINOPATHY: CLINICALLY SIGNIFICANT MACULAR EDEMA

Focal grid laser photocoagulation is indicated for clinically significant macular edema defined as any one of the following: (1) retinal thickening within 500 μm of the center of the macula; (2) lipid exudates within 500 μm of the center of the macula associated with retinal thickening; or (3) retinal thickening greater than 1 disc area within 1 disc diameter of the center of the macula.

Technique

Clinically significant macular edema is diagnosed with use of a fundus contact lens. Once this diagnosis is established by clinical examination, a fluorescein angiogram is obtained to identify treatable lesions. Treatable lesions include discrete points of hyperfluorescence or focal leakage (eg, microaneurysms), areas of diffuse leakage (eg, intraretinal microvascular abnormalities, capillary bed leakage), and areas of capillary nonperfusion (except for the normal foveal avascular zone).

After obtaining the patient's informed consent, laser photocoagulation is performed using a slit lamp delivery system with a fundus contact lens. There are several lenses designed to optimize viewing of the macula. Many physicians prefer to use yellow-wavelength energy, if available, for the treatment of microaneurysms (preferential absorption by hemoglobin). Since the yellow wavelength can be absorbed by intraretinal hemorrhage, these areas should be avoided to reduce the risk of severe retinal damage. Laser settings are 50- μm to 100- μm spot size, 0.1- to 0.15-second duration, and intensity to achieve mild retinal whitening.

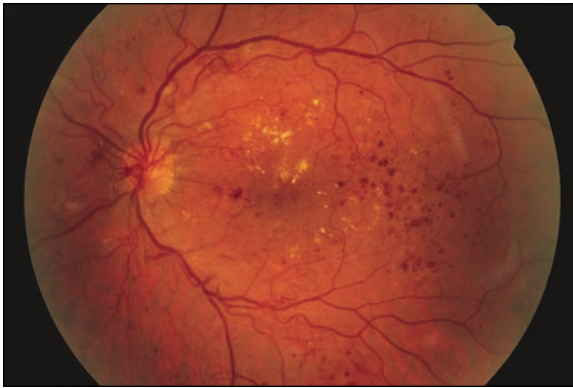
Direct treatment is applied to areas of focal leakage. Sufficient intensity should be used to obtain definite whitening around the microaneurysm or site of leakage. For larger microaneurysms, the surgeon should attempt to obtain whitening (or darkening) of the microaneurysm itself. A grid pattern of laser burns should be applied to areas of diffuse leakage or capillary nonperfusion.

Complications

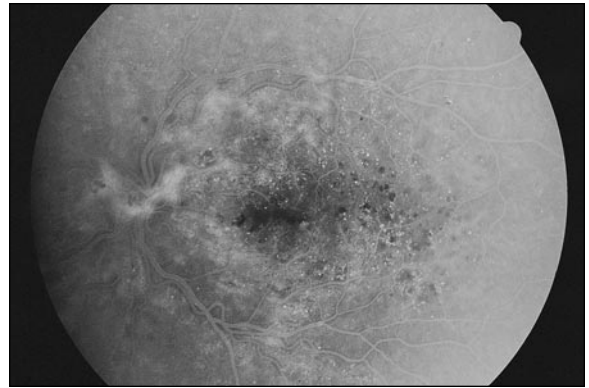
Great care must be taken to avoid treatment of the fovea. In eyes with central macular edema, the normal foveal landmarks may be unrecognizable. Having the patient fixate on the laser-aiming beam while the laser is in the standby setting may facilitate identification of the center of the macula. In addition to inadvertent foveal burns, complications of macular photocoagulation include reduced vision, paracentral and central scotomas (temporary or permanent), choroidal neovascularization, and subretinal fibrosis.

Follow-up Considerations

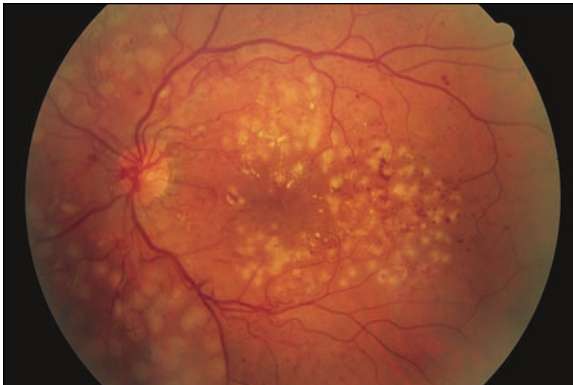
Patients are reexamined within 6 to 8 weeks to evaluate the response to laser treatment. It is not unusual to see a temporary increase in the amount of lipid exudate as the macular edema resorbs. Three to 4 months following the laser session, additional macular laser photocoagulation may be performed in eyes with residual clinically significant macular edema. Treatment of lesions up to 300 μm from the center of the macula may be performed, unless there is perifoveal capillary dropout.



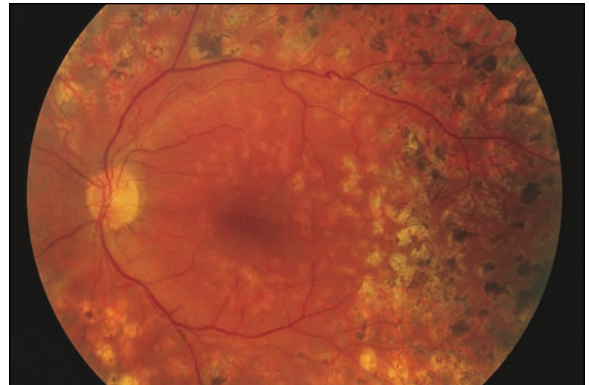
This 34-year-old man presented with high-risk proliferative diabetic retinopathy and clinically significant macular edema. He met all three criteria for clinically significant macular edema.



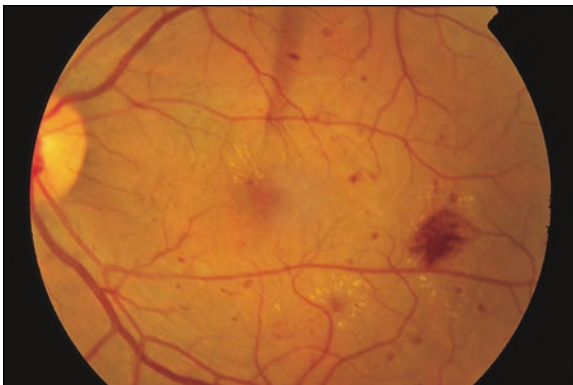
A fluorescein angiogram was obtained to identify treatable lesions. Numerous hyperfluorescent spots are consistent with microaneurysms scattered throughout the macula. Also present is hyperfluorescence of the optic disc consistent with neovascularization.



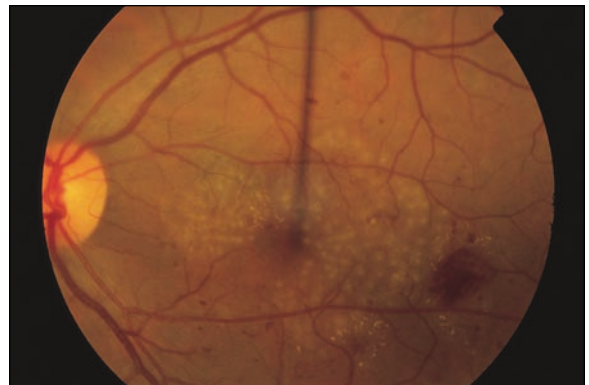
Macular laser was applied to the microaneurysms; care was taken to avoid the fovea. Laser parameters were 50- μ m spot size; 0.1-second duration; and intensity to obtain whitening (or darkening) of the microaneurysm. Nasal panretinal photocoagulation was initiated at the same time.



The patient did very well with resolution of the macular edema and regression of the neovascularization.



Fundus photograph of the left eye in a patient with diabetes and clinically significant macular edema.



Fundus photograph of the same patient following grid laser photocoagulation to the area of retinal thickening.

DIABETIC RETINOPATHY: HIGH-RISK PROLIFERATIVE DIABETIC RETINOPATHY

Panretinal photocoagulation (PRP) is indicated for the treatment of high-risk proliferative diabetic retinopathy (PDR). High-risk PDR is defined as three or four of the following risk factors: (1) new vessels present; (2) new vessels on or within 1 disc diameter (DD) of the optic disc (NVD); (3) severe new vessels (NVD greater than one-third disc area or in the absence of NVD, neovascularization elsewhere [NVE] greater than one-half disc area); or (4) preretinal and/or vitreous hemorrhage.

The presence of these conditions translates into three clinical scenarios: NVD greater than one-third disc area; any NVD associated with preretinal or vitreous hemorrhage; and NVE greater than one-half disc area associated with preretinal or vitreous hemorrhage. Iris neovascularization and neovascular glaucoma also require prompt PRP. In eyes with less severe PDR or severe nonproliferative diabetic retinopathy, the treating ophthalmologist must weigh the benefits of early PRP with the potential adverse effects.

Technique

Informed consent must be obtained from the patient before PRP is performed. Treatment with PRP may be performed with topical or retrobulbar anesthesia, and it may be conducted in one or multiple sessions. Most surgeons complete PRP in two treatment sessions. Both binocular indirect ophthalmoscopic and slit lamp laser photocoagulation delivery systems may be used. A variety of wide-field contact lenses are available for standard PRP. Many of the commercially available lenses magnify the spot size 1.5 to two times at the retina and provide an inverted and reversed image of the fundus. Yellow and/or green wavelengths are most commonly employed; red may be used in patients with significant cataract or vitreous hemorrhage. Common laser parameters are 200- μ m to 500- μ m spot size; 0.1- to 0.2-second duration; and intensity to produce a moderately white burn. The average number of 500- μ m spots needed to complete PRP is approximately 1500. Laser burns are spaced one-half to one spot width apart.

The placement of laser burns in a posterior to anterior direction helps to reduce the risk of inadvertent extension into the macula. The posterior fundus is demarcated with two to three rows of laser burns. The posterior border should be placed approximately one-half to 1 DD from the optic disc nasally and the major retinal vascular arcades superiorly and inferiorly. The temporal border is at an imaginary line located approximately 2 disc-to-fovea diameters from the optic disc.

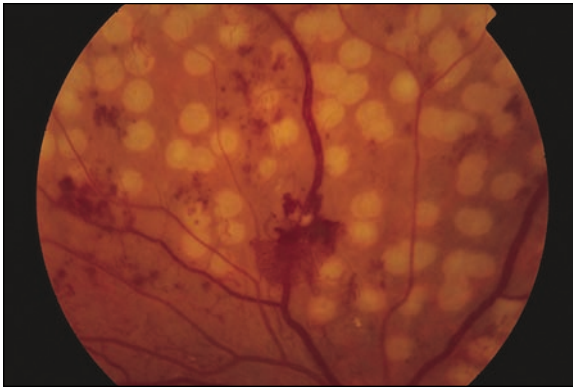
Complications

Complications of PRP include blurred vision, nyctalopia, visual field constriction, poor color discrimination, transient myopia, accommodation defects, corneal burns, narrow-angle glaucoma, iris burns, lens opacities, inadvertent macular burns, macular edema, exudative macular detachment, ciliochoroidal effusion, choroidal/choriovitreous neovascularization, optic neuropathy, and complications of local anesthesia (globe trauma, retrobulbar hemorrhage).

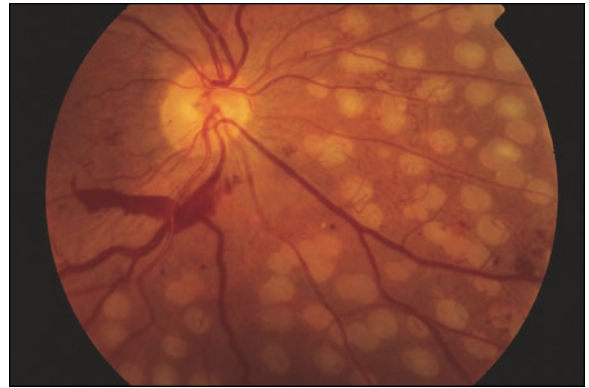
Follow-up Considerations

A follow-up visit is scheduled 2 or 3 weeks after the photocoagulation for additional laser treatment if divided sessions are used or in 1 month following completion of PRP. In eyes that fail to regress despite standard PRP, supplemental PRP may be helpful.

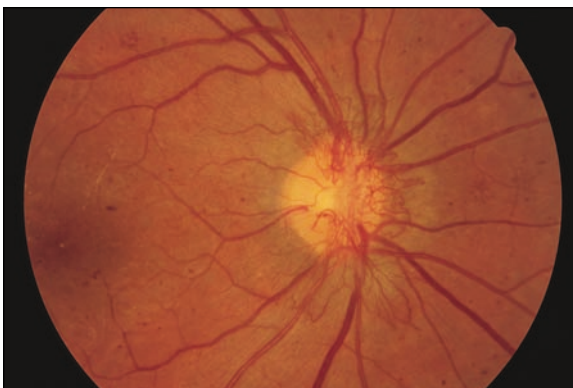
Supplemental laser therapy is indicated for the failure of neovascularization to regress, increasing neovascularization or new areas of neovascularization, or vitreous hemorrhage associated with active neovascularization.



Panretinal photocoagulation is usually divided into 2 sessions. On average, a total of 1200 to 1600 burns of 500- μ m spot size are necessary to complete the laser treatment.



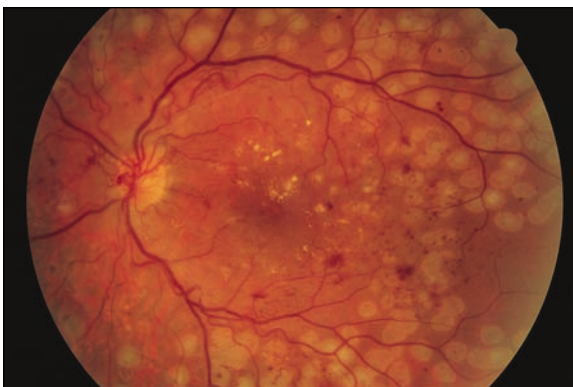
Burns are placed one burn width apart, and care is taken to avoid treatment of the major vessels.



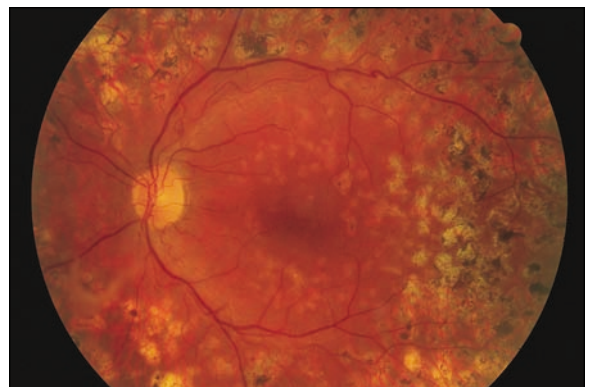
The efficacy of panretinal photocoagulation is related to the regression of retinopathy risk factors. This patient had high-risk proliferative diabetic retinopathy with greater than one-third disc area of neovascularization of the disc.



Two weeks following laser treatment, the neovascularization of the disc is significantly regressed.



Fundus photograph of a man with high-risk proliferative diabetic retinopathy immediately following panretinal photocoagulation.



Fundus photograph of the same patient, two years following his initial laser treatment. The old laser scars demonstrate variable levels of atrophy and hyperpigmentation. Successful laser therapy results in regression of the neovascularization and reduction of the venous caliber. The results are long lasting.

PERIPHERAL RETINAL NEOVASCULARIZATION

A variety of conditions are associated with peripheral retinal neovascularization. These include retinopathy of prematurity (ROP), sickle cell retinopathy, peripheral branch retinal vein occlusions (BRVO), familial exudative vitreoretinopathy (FEVR), Eales' disease, pars planitis, and sarcoidosis. The unifying feature of all of these conditions is peripheral retinal ischemia. Laser photocoagulation is applied to the peripheral ischemic retina to reduce the stimulus for new vessel formation.

Technique

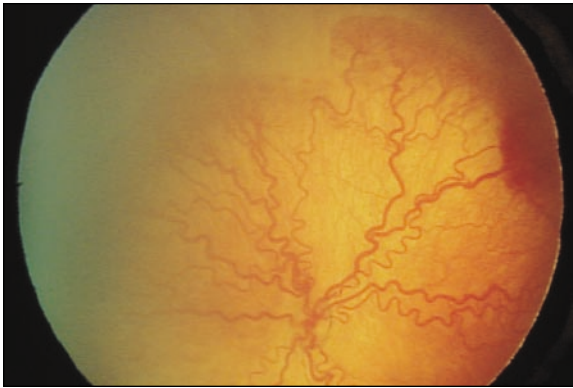
Informed consent must be obtained from the patient before laser photocoagulation is performed. Fluorescein angiography may be helpful in identifying the areas of retinal capillary nonperfusion. Peripheral scatter laser photocoagulation may be performed with either a slit lamp or binocular indirect ophthalmoscopic laser delivery system. For infants with ROP, binocular indirect ophthalmoscopic laser photocoagulation has been proved to be as effective as peripheral retinal cryotherapy for threshold ROP and has become the treatment of choice among those caring for these premature infants. Treatment parameters for binocular indirect ophthalmoscopic laser photocoagulation include a duration between 0.2 and 0.5 second and power intensity to obtain moderate retinal whitening. The spot size is determined by the power of the indirect condensing lens, the refractive state of the patient's eye, and the distance between the patient and the surgeon. The average spot size achieved with a 20-diopter lens is approximately 400- μ m. Scatter laser burns are placed one-half to one burn width apart in the region of the ischemic retina. For threshold ROP, a more confluent pattern of laser burns is generally necessary to induce regression of the neovascularization.

Complications

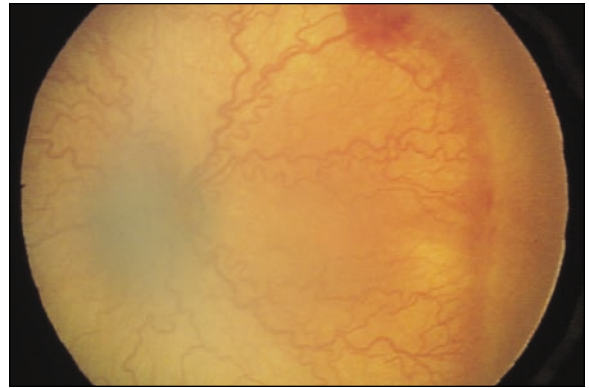
Complications of peripheral scatter laser treatment include blurred vision, nyctalopia, visual field constriction, poor color discrimination, transient myopia, accommodation defects, corneal burns, narrow-angle glaucoma, iris burns, lens opacities, inadvertent macular burns, macular edema, exudative macular detachment, cilio-choroidal effusion, choroidal/choriovitreal neovascularization, optic neuropathy, and complications of local anesthesia (globe trauma, retrobulbar hemorrhage).

Follow-up Considerations

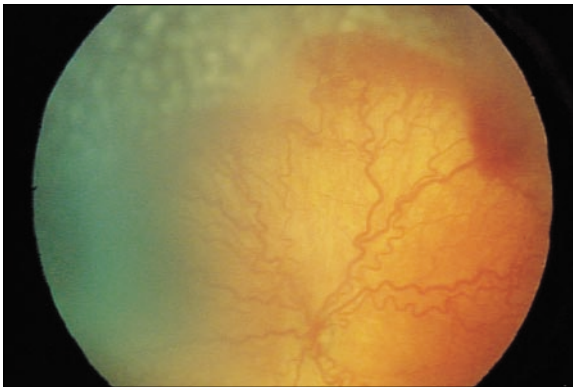
Patients should be reexamined approximately 2 to 4 weeks after laser photocoagulation to ensure regression of the neovascularization. Neonates with ROP are usually examined 1 week following laser photocoagulation. Supplemental laser therapy is recommended for eyes in which regression of the neovascularization fails.



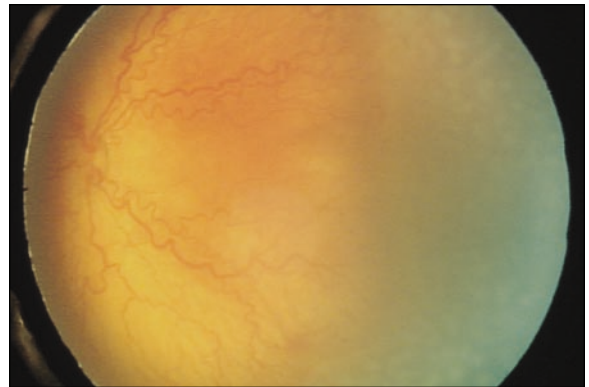
Fundus photograph of a baby with threshold retinopathy of prematurity. Note the fibrovascular proliferation with preretinal hemorrhage in the upper right aspect of the photograph. Plus disease is present with vascular dilation and tortuosity.



This fundus photograph of the same baby demonstrates the extent of the stage 3 retinopathy of prematurity as it involves the entire temporal retina.



Fundus photograph of the same baby taken immediately following laser photocoagulation. Laser spots are visible in the upper left side of the photograph.



The laser burns are placed in the peripheral avascular retina to reduce the stimulus for neovascularization. A binocular indirect ophthalmoscopic laser delivery system is used. The intensity is adjusted to obtain a moderately white burn in a confluent pattern.

RETINAL ARTERIAL MACROANEURYSM

Laser photocoagulation is indicated for the treatment of retinal arterial macroaneurysms complicated by exudative macular edema involving the fovea. Ruptured macroaneurysms characterized by subretinal, intraretinal, and preretinal hemorrhage often resolve spontaneously without the need for laser treatment.

Technique

Informed consent from the patient must be obtained before performing laser photocoagulation. A fluorescein angiogram is helpful in delineating the size and location of the macroaneurysm. Retinal arterial macroaneurysms are treated at the slit lamp with use of a fundus contact lens. Topical anesthesia is used for most patients. Yellow and/or green wavelengths are used because of the preferential absorption by hemoglobin. A lower-intensity, longer-duration (0.2- to 0.5-second) burn is recommended to reduce the risk of aneurysm rupture during the treatment session. A spot size of 200- μ m to 500- μ m is sufficient. The outside margin of the macroaneurysm is treated to obtain mild whitening. The body of the aneurysm may be treated directly following successful treatment of the peripheral margin. Again, the end point is mild to moderate retinal whitening.

Complications

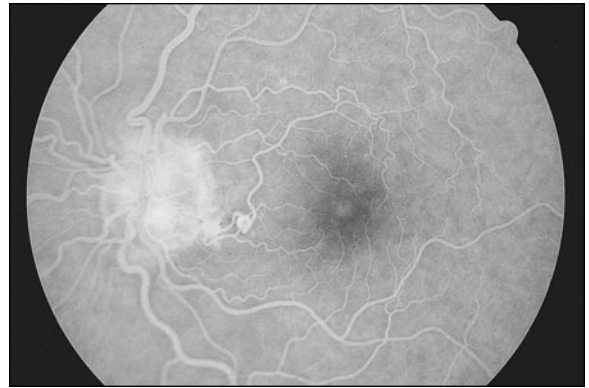
Complications of laser photocoagulation for retinal arterial macroaneurysms include loss of vision, aneurysm rupture, and branch retinal artery occlusion. It is not unusual to see an increase in the amount of lipid exudate initially as the edema resorbs; this may be the cause of temporary visual loss following laser photocoagulation.

Follow-up Considerations

Patients should be reexamined approximately 1 month following laser photocoagulation. Multiple treatment sessions may be necessary to achieve closure of the macroaneurysm.



This 68-year-old woman had visual loss in her left eye as a result of macular edema. She had a macroaneurysm along a small inferior branch retinal arteriole. Associated lipid exudation extends through the fovea.



Fluorescein angiogram of the same patient identifies the aneurysm site along an anomalous retinal arteriole. Laser photocoagulation was applied to the margins of the macroaneurysm to reduce the risk of retinal arterial occlusion.



This fundus photograph of the same patient, taken 1 month following laser treatment, reveals intraretinal hemorrhage at the macroaneurysm site and more prominent lipid exudate throughout the macula. The patient's vision declined from 20/60 to 20/100.



Approximately 6 months following laser treatment, the macular edema and lipid exudate resolved, and the patient's vision improved to 20/25.

RETINAL TEARS AND RETINAL DETACHMENT

The goal of laser retinopexy is to prevent retinal detachment or to prevent progression of a limited retinal detachment. It is, therefore, essential to detect retinal breaks that are at risk for causing a retinal detachment. Certainly treatment is indicated for most horseshoe-shaped retinal tears in patients who are acutely symptomatic and, while convincing evidence may be lacking, probably also for any break associated with subretinal fluid or a retinal dialysis. Lattice degeneration without breaks or with round atrophic holes, operculated retinal holes, and retinoschisis without detachment generally do not need to be treated. A history of retinal detachment in the fellow eye or a strong family history of retinal detachment or other planned intraocular surgery may lower one's threshold to treatment in selected cases.

Technique

The goal of laser treatment is to create a chorioretinal scar or adhesion to prevent the accumulation of liquid vitreous in the subretinal space. To achieve this, typically three rows of closely spaced laser burns are used to encircle the retinal break or retinal detachment. Laser photocoagulation must be applied to attached retina and, in situations where subretinal fluid extends to the ora serrata and the lesion cannot be adequately surrounded by laser, the laser retinopexy should go from the ora serrata on one side to the ora serrata on the other side.

Most patients can tolerate treatment with topical anesthesia alone. However, if the patient cannot tolerate the required treatment with only topical anesthesia, it is better to proceed with peribulbar or retrobulbar anesthesia than risk leaving the patient with inadequate treatment. Either the slit lamp or indirect laser delivery systems can be used. Argon green laser is the wavelength of choice except in the setting of a significant vitreous hemorrhage where krypton red laser may be preferable. For the slit lamp delivery system, the Goldmann three-mirror contact lens or a wide-angle biconcave lens can be used. A spot size of 200- μ m or greater, a duration of 0.1 to 0.2 second, and a power titrated up from 150 mW to achieve a gray-white burn are the starting parameters of choice. For the three rows of laser burns surrounding the retinal break, spots are placed approximately one-half spot width apart.

The indirect laser delivery system allows treatment of more peripheral retina. A 20- or 28-diopter condensing lens is used with the patient in a supine position. A green or red wavelength may be used with the following starting parameters: duration of 0.1 to 0.2 second and a power titrated up from 200 mW to achieve a gray-white burn. While most patients can tolerate indirect laser treatment with a topical anesthetic, this type of laser

delivery often causes more discomfort, and retrobulbar or peribulbar anesthesia may be necessary.

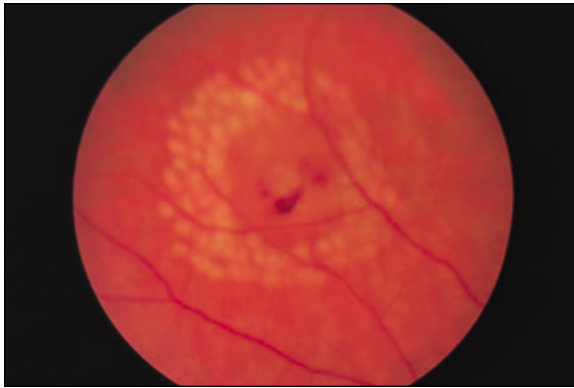
Complications

Although the goal of laser treatment is to prevent retinal detachment, it is unfortunately not always achievable. With an inadequate laser barrier, or even in the presence of a satisfactory laser barrier, ongoing vitreous traction can result in an extension of the tear and progression of subretinal fluid beyond the laser barrier. It should also be noted that 15% to 20% of patients who have an acutely symptomatic posterior vitreous detachment in association with a retinal tear may develop new tears in the first 4 weeks of their acute symptoms. Patients need to be carefully counseled that a posterior vitreous detachment is a dynamic process and that they should return immediately for an examination if they experience any new visual symptoms. Patients should also be made aware of the fact that the purpose of laser treatment is to prevent retinal detachment; the laser therapy will have no effect on their floaters and or flashes.

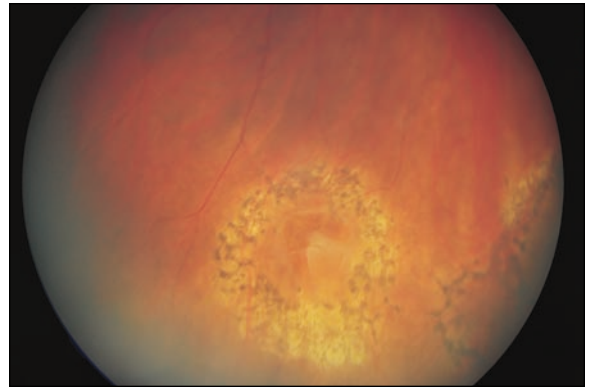
Both retinal tears and laser retinopexy are risk factors for the development of epiretinal membranes. It is hard to separate the contribution of each, but in patients who require extensive laser retinopexy, it may be reasonable to discuss the possible late development of premacular gliosis.

Follow-up Considerations

Following laser retinopexy, patients are typically asked to return in 1 week's time or sooner should any new symptoms develop. Careful examination of the retinal periphery should be undertaken with indirect ophthalmoscopy with 360° of scleral depression to monitor for new retinal breaks and to ensure adequacy of the original laser treatment. Patients are then asked to return 3 to 4 weeks after that, when a similar careful and thorough examination of the retinal periphery is undertaken.



Fundus photograph taken immediately following laser photocoagulation for an acute, symptomatic horseshoe-shaped retinal tear. Approximately three rows of laser burns are placed around the retinal tear to reduce the risk of retinal detachment.



This fundus photograph demonstrates a well-treated retinal flap tear. The chorioretinal scarring generated by laser photocoagulation prevents the passage of fluid through the retinal tear.

RETINAL TELANGIECTASIS AND RETINAL ANGIOMAS

Laser photocoagulation is indicated for the treatment of Coats' disease, idiopathic juxtafoveal retinal telangiectasis group 1, and occasional cases of idiopathic juxtafoveal retinal telangiectasis group 2 complicated by subretinal neovascularization. Isolated retinal angiomas and retinal angiomas associated with von Hippel-Lindau disease may be successfully treated with laser photocoagulation.

Technique

Informed consent must be obtained from the patient prior to laser photocoagulation. Laser photocoagulation may be performed with a slit lamp or binocular indirect ophthalmoscopic laser delivery system. Yellow and/or green wavelengths are most effective because of their preferential absorption by hemoglobin. Fluorescein angiography is helpful in identifying retinal telangiectasis as well as areas of peripheral capillary nonperfusion. Telangiectatic vessels are treated directly with moderately intense, confluent laser burns; peripheral scatter laser photocoagulation is applied to areas of capillary nonperfusion. Multiple sessions may be required to achieve successful closure of the telangiectatic vessels.

Laser photocoagulation for subretinal neovascularization in patients with idiopathic juxtafoveal retinal telangiectasis is similar to that described in patients with choroidal neovascularization. (See "Choroidal Neovascularization" earlier in this chapter.)

Retinal angiomas may require multiple treatment sessions to achieve closure. Again, yellow and/or green wavelengths are most effective because of their preferential absorption by hemoglobin. Treatment is applied directly to the tumor with sufficient intensity to obtain a moderately intense white burn. The typical spot size is 200- μ m to 500- μ m with a 0.2- to 0.5-second duration.

Complications

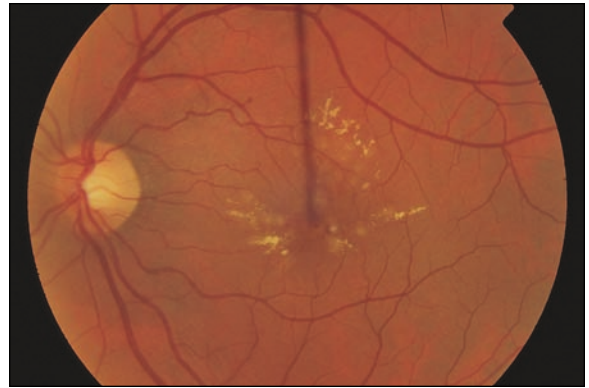
Complications of laser photocoagulation for retinal telangiectasis and retinal angiomas include loss of vision. It is not unusual to see an increase in the amount of lipid exudate initially as the edema resorbs; this may be the cause of temporary visual loss following laser photocoagulation.

Follow-up Considerations

Multiple treatment sessions may be necessary to successfully treat retinal telangiectasis. Treatment may be applied at 8- to 12-week intervals. Patients with extensive Coats' disease must be treated aggressively because of the risk of exudative retinal detachment, neovascular glaucoma, and phthisis bulbi.



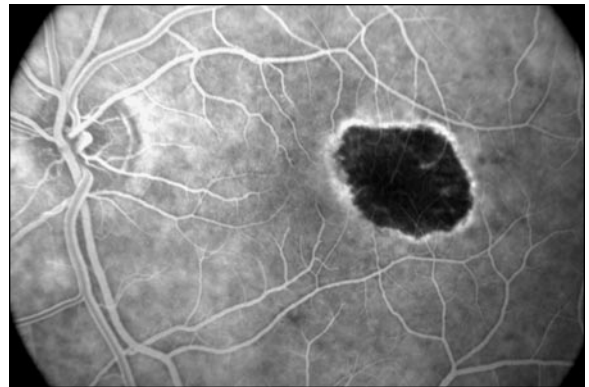
Fundus photograph of a patient with idiopathic juxtafoveal retinal telangiectasis group 1, demonstrating visible microaneurysms, lipid exudate, and macular edema in his left eye.



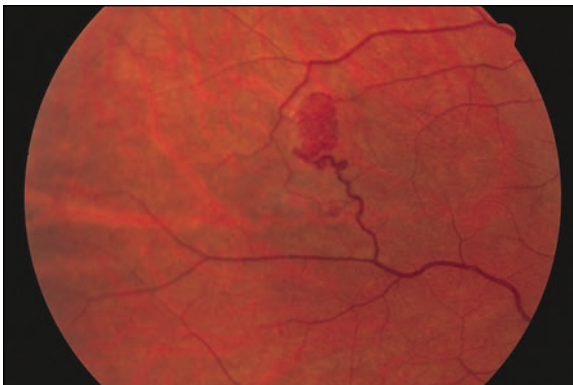
Fundus photograph of the left eye of the same patient immediately after focal laser treatment to the leaking retinal vascular abnormalities.



This man with idiopathic juxtafoveal retinal telangiectasis group 2 developed an extrafoveal subretinal neovascular membrane in his left eye. Fluorescein angiography demonstrates a well-defined extrafoveal neovascular complex.



Laser photocoagulation was performed on the same patient. Fluorescein angiography demonstrates prominent hypofluorescence of the laser-treated area, with no evidence of persistent or recurrent neovascularization.



Von Hippel-Lindau disease is characterized by the presence of retinal capillary hemangiomas. This woman had a small angioma with a prominent draining vessel. There was no significant fluid or lipid exudation.



Laser photocoagulation was performed on the same patient. The retinal capillary angioma was treated directly with intense laser photocoagulation to achieve closure. Some individuals experience exacerbation of fluid and lipid exudation following treatment.

PHOTODYNAMIC THERAPY WITH VERTEPORFIN

Photodynamic therapy (PDT) with verteporfin is indicated for the treatment of predominantly classic, subfoveal choroidal neovascular membranes associated with age-related macular degeneration (AMD), presumed ocular histoplasmosis syndrome, and pathologic myopia. The role of PDT in other conditions associated with choroidal neovascularization (eg, choroidal rupture, angioid streaks, multifocal choroiditis) is being investigated.

Contraindications for PDT with verteporfin include pregnancy, liver disease, porphyria, or known hypersensitivity to verteporfin.

Technique

Informed consent must be obtained from the patient to conduct PDT. Fluorescein angiography is necessary to identify the location and type of choroidal neovascularization. Photodynamic therapy is most effective for subfoveal new vessels that are predominantly classic (classic component occupies at least 50% of the entire choroidal neovascular complex). Classic choroidal neovascularization is characterized by a well-defined, lacy pattern of vessels early in the fluorescein angiogram followed by late leakage. The size of the treatment area is usually limited to 5400 μm or smaller.

The dosage of verteporfin is based on the patient's total body surface area calculated using the patient's height and weight. According to the patient's body surface area, a verteporfin dosage of 6 mg/m² is prepared. To form a total volume of 30 mL, 5% dextrose is added.

The medication is infused through an arm vein over 10 minutes (using an infusion pump set to deliver 3 mL of solution per minute). Following a 5-minute waiting period, the medication is activated with a 689-nm wavelength of light for 83 seconds. The light dose is 50 J/cm² or 600 mW/cm², which is automatically set by the photoactivator.

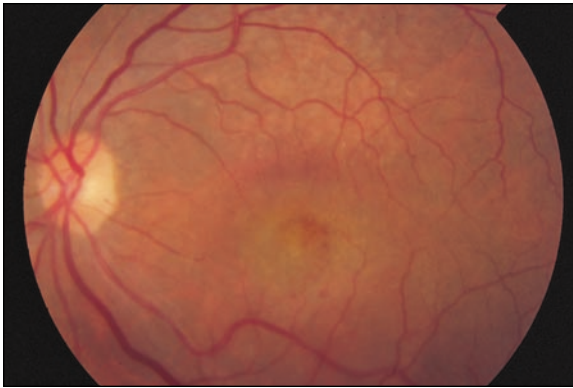
The size of the treatment area is determined by adding 1000 μm to the greatest linear diameter of the choroidal neovascular complex. The greatest linear diameter can be calculated manually or measured with commercially available computer software. There are no visible funduscopic changes during or immediately following treatment.

Complications

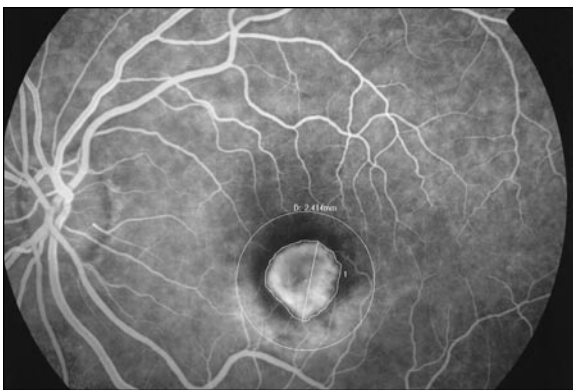
The patient must be observed closely during the infusion process. In the event of extravasation, the infusion must be stopped immediately. Complications of PDT include visual disturbance (blurred vision, scotoma), infusion-related complications (rash, extravasation of medication), photosensitivity, headache, back pain, and allergic reaction. Severe visual loss may occur in 1% to 4% of patients. This may be related to macular infarction or optic nerve damage. Patients must avoid exposure to direct sunlight for 5 days following the infusion to reduce the risk of skin damage.

Follow-up Considerations

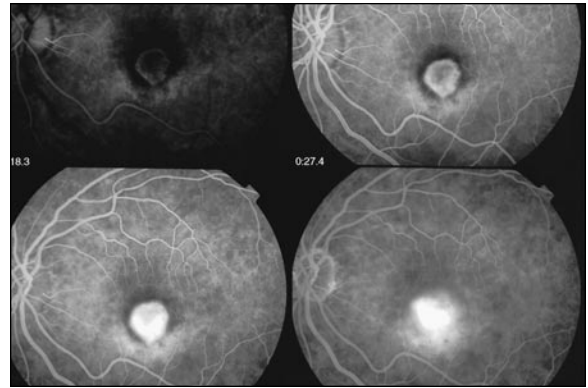
Patients are reevaluated every 3 months. Fluorescein angiography is performed to determine if leakage persists from the choroidal neovascular complex. If leakage is detected, additional PDT is recommended. Most individuals require 5 to 6 treatments over the course of 2 years.



Fundus photograph of a patient's left eye with a subfoveal choroidal neovascular membrane secondary to age-related macular degeneration and 20/400 vision.



Top-Con Imagenet software is used to help calculate the spot size to be used for photodynamic therapy. The spot size is set to cover a diameter of 1000 μm larger than the greatest linear dimension of the choroidal neovascular membrane.



Early (upper left), midphase (upper right and lower left), and late-phase (lower right) fluorescein angiograms demonstrate an entirely classic subfoveal choroidal neovascular membrane secondary to age-related macular degeneration. Such classic small lesions with poor vision did especially well with photodynamic therapy as compared to controls in the Treatment of Age-Related Macular Degeneration with Photodynamic Therapy (TAP) study.

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